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Agricultural Experiment Station.

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NOTES ON THE INSECTICIDE USE OF THE GASOLINE BLAST LAMP

By S. A. FORBES, State Entomologist.

The use of the ordinary plumber's torch, or some modification of it, for the destruction of injurious insects on their food plants seems to have occurred independently to several persons during the last few years, and to have been tried with some care as a practical measure by several disinterested men competent to make exact observations and to report results without bias or prejudice.

Mr. S. A. McHenry, recently superintendent of one of the horticultural substations of the Texas Agricultural Experiment Station, is reported to have used it for several years against the harlequin cabbage-bug, and Professor J. M. Stedman, of the Missouri Experiment Station, has also used it against the same insect. Professor R. H. Pettit, of the Michigan Agricultural College, tried it on the San Jose scale as far back as 1897, publishing in the Bulletin of the Michigan Experiment Station the earliest report of an exact experiment with it which I have seen; and Professor Carig, of the Horticultural Department of Cornell University, has also tried it on this scale. Professor E. Dwight Sanderson, of the Texas Agricultural College and Experiment Station, has used a form of it on the cotton boll-weevil. Professor Thomas B. Symons, of the Mary-

land Agricultural College and Experiment Station, used it experimentally on the San Jose scale, and on beetles infesting the aster. Professor J. L. Phillips, State Entomologist of Virginia, has also tested it on the San Jose scale with unusual thoroughness; Professor F. M. Webster, Entomologist of the Ohio Agricultural Experiment Station, had it tried four years ago by an assistant, Mr. C. W. Mally (now Government Entomologist in Cape Colony, South Africa), on a variety of insects, including the chinch-bug; and two of my own assistants, Mr. E. S. G. Titus and Mr. G. I. Reeves, have used it on scale insects, caterpillars, and moths, have tested it for the destruction of fungus parasites of the green leaf, and have determined its effects on various kinds of vegetation when applied in a way to kill the insect enemies of the plant. Most of these experiments are unpublished, but their results have been generously placed at my disposal for use in this brief discussion.

Although no one of those here mentioned has made a trial of the gasoline torch for all the insecticide and fungicide purposes which it might possibly serve, the total results have a considerable value as showing definitely some things which can and some things which can not be done with it, and as indicating the directions in which further trials may be made if, indeed, it appears that further trial is necessary or worth while. Some variation and conflict in the reports of some of these experiments are evidently due to differences in the apparatus used, this varying from a poorly constructed and feeble torch, made in Illinois especially for insecticide work, to a large and powerful blast-lamp, used in Texas for burning the thorns off prickly-pears.

The idea that exposed insects of small size may be quickly destroyed by the sudden and brief application of a blast of very hot air, or even of actual flame, without injury to the plant on which they may be feeding at the time, strikes one favorably at first thought; and there seems, in advance, to be no obvious reason why this method may not have a considerable practical value. The living animal is often more sensitive to sudden heat exposures than the living plant, and the margin between exposures fatal to each may, in some cases, be so wide as to make this method fairly safe in ordinary practice. The smaller the insect, of course the more quickly it may be killed by the hot blast; and the better the living tissue of the plant is protected by a lifeless cuticle or a layer of bark, the longer it may be exposed to this blast without being heated to the point of injury. Bark-lice on trees and shrubs are thus favorable objects for experiment; but where thick-bodied insects, like caterpillars and large beetles or bugs, themselves covered with a dense crust of lifeless cuticle, are feeding on the young green leaf, the margin of safety is greatly narrowed and may wholly disappear. The practical utility of this method of destroying insects in any case, evidently depends on the existence and extent of this margin of safety.

The gasoline blast may, in fact, be used to kill any insect on any plant. The time and method of use necessary to kill the insect will vary widely for different kinds of insects and for the different states and stages of each kind; and the time and method of use sufficient to injure various kinds of plants will likewise differ widely according to the kinds and condition of the plants themselves. The actual effect of the blast on either insect or plant will also vary enormously according to small details of the method by which it is applied. They will vary, first, with variations in the pressure, which determines the extent and heat of the flame; second, with the distance from the object at which the torch is held; third, with the rate of movement at which the flame is passed over the surface treated; fourth, with the temperature at the time and the amount and direction of the wind; fifth, with the direction of the blast, whether perpendicular or oblique to the surface; and sixth (not to specify further), with the steadiness with which the flame is applied to a given surface, whether held at one point for a definite time or swayed back and forth over a considerable surface for a variable number of times.

To determine the effect of all these different classes of variations with sufficient exactness for practical guidance, and then to combine all the various results of this inquiry with each other in a way to form a system of practice which can be accurately described and safely recommended for general use, is a task which no intelligent investigator would enter upon lightly, or without such preliminary tests as would enable him to judge whether any important result was likely to come from more exact and extensive experiments. The observations here reported are all in the nature of such preliminary tests, made by different persons, each for his own satisfaction, on different objects, and in different parts of the country. They are practical tests rather than complete scientific experiments, and their value is hence suggestive rather than final. Those which have to do with the San Jose scale, the harlequin cabbage-bug, and the cotton boll-weevil are perhaps of the greatest interest, and will be given first.

The San Jose Scale.—In the fall of 1897, Professor Pettit, of Michigan, had five parallel burners fitted to an ordinary plumber's blast lamp in such a way that a flame about ten inches wide could be directed against the surface of a tree, and several trials of this apparatus were made during the following winter on peach- and pear-trees badly infested with the San Jose scale. "The heat produced by this lamp," he says, "is very intense, and great care must be observed not to allow the flame to remain at any one point long enough to injure the tree. The best results were obtained when the flame was steadily moved so that it covered a space of a yard in length in from five to ten seconds. The results seemed to show that the blast will kill the scale-insects with

little or no injury to the tree. The trees were scorched in places where the flame had moved too slowly, and the care necessary to avoid the scorching appears to be the most serious drawback to the use of the blast lamp. In careless hands much injury may be done in a very short time, while the skillful handling necessary for success would be rather expensive under ordinary circumstances. Good judgment must be exercised always, and the rapidity and effectiveness of the work will be much modified by the temperature of the air, the direction and force of the wind, the age of the trees and the thickness of the incrusting scales." Referring to these statements in a recent letter, Professor Pettit writes that he intended that the lamp should be used only in connection with a spray for burning off or loosening the outer layers of a crust of scales so that a fluid insecticide might penetrate to those beneath. "I now realize," he says, "that the same effects may be obtained much more cheaply in other ways."

By Professor Craig, of Cornell University, a torch much advertised for the destruction of insects was used, May 19, 1903, against the San Jose scale on the apple, medlar, buffalo-berry, and dogwood. Different branches were flamed in various ways to ascertain the time necessary to kill the scale and to determine the minimum exposure to the flame of the torch which would kill the cambium layer of the tree or shrub. In respect to time of exposure three methods of treatment were used: passing the flame so rapidly over the surface that it merely touched each point for an instant; moving it at the rate of one foot per second; and holding it stationary on the infested spot long enough to count one. The scales were reported to have been killed in every case save one, in which a twig of dogwood had been very rapidly flamed. "The general results," writes Professor Slingerland, "were summarized as follows: First, the torch is impracticable for large trees of apple, plum, pear, peach, or cherry, because of the amount of time required to flame the whole tree. It would take a man several hours thus to go over one large tree; second, there is great danger of injuring buds or the cambium layer on thin-barked trees; third, the torch might be used on small nursery stock or ornamental shrubs by an experienced operator who knew exactly what time to expose the plant to the flame."

Professor Phillips, of Virginia, made use, against the San Jose scale, in 1903, of a torch sent by the manufacturing company for trial to Professor Alwood, of that state. "March 28 of this year," he says, "I used this gasoline torch on two apple-trees four years of age. These trees were moderately infested with the San Jose scale, and were treated by running the torch over the surface several times. One tree was exposed to the torch about twice as long as the other. This treatment did not appear to injure the trees, neither did it kill a perceptible number of insects.

"I was not satisfied with this trial, however, and detailed a student assistant, Mr. E. F. Cole, to test the torch, which he did August 7. The tree treated was a four-year-old apple, badly crusted with the San Jose scale. As it would be entirely impracticable to use this torch against the San Jose scale during the summer, this treatment was confined almost entirely to the trunks and main branches of this tree, but in treating the tree in this manner, of course a few of the leaves were also reached by the flame. The treatment was so severe that the leaves on the treated portions of the tree were killed at once, and when examined on August 20, portions of the bast tissues of the bark were found injured also. Quite a large number of scale insects were alive at that date.

"Judging from these two tests, I consider that the use of this torch is quite tedious and impracticable, even on small trees. Besides, such a small per cent. of the San Jose scales were destroyed by it, even where the trees were seriously injured by its use, that I do not consider it a practicable remedy."

Professor Symons, of Maryland, writes me that he personally conducted some experiments with the same kind of a torch on different varieties of peach and plum infested by the San Jose scale, but that the results were not at all satisfactory. Although the insects were dead two weeks later on the parts which had been hit by the flame, young scales were crawling about over the surface in considerable numbers, showing that it had been impossible to reach all parts of the tree, especially at the ends of the branches. If used when the tree was in leaf he could not avoid burning the foliage. As a result of his experiments, Professor Symons concludes that it is impracticable to control the San Jose scale with this torch.

To these observations by experts I may add a note of a trial of the torch made by a practical gardener, on some infested trees belonging to J. W. Stanton, of Richview, in this state. By oversight, these trees were sprayed with whale-oil soap before they had been critically examined as to the final effects of the blast on the San Jose scale; but Mr. Stanton writes me that from what he could see of the effects of the treatment at the time, he is of the opinion that it would not be successful on tree fruits. One of my horticultural inspectors, Mr. R. W. Braucher, happened, however, to examine one of these trees after the treatment with the torch and before the application of the whale-oil soap, and found that the bark was scorched in some places, and that in others the scales were still alive.

From the foregoing experiments, it is clear that the gasoline torch has at best only a very limited application in the treatment of trees infested by the San Jose scale. It might be occasionally used to advantage, as suggested by Professor Pettit, to burn off the outer part of an unusually thick crust of scales on the trunk and largest branches of a tree,

preliminary to a treatment with the lime-and-sulphur wash. As this insecticide does not penetrate readily to any great depth, it is sometimes necessary to repeat a spraying after a time if the tree is too thickly incrusted. This second spraying might perhaps be omitted if the torch were first used on the crust of scales. It would be the merest folly, however, to think of using it as a substitute for an insecticide spray in the treatment of the San Jose scale, or for any general treatment of orchard trees for any purpose whatever.

This torch was also tried on certain other orchard scales at Urbana during the fall of 1902, but for reasons to be given presently these tests are reported separately farther on.

THE HARLEQUIN CABBAGE-BUG.—The introduction of the use of the gasoline torch against the harlequin cabbage-bug in the South seems to be due to Mr. S. A. McHenry, recently superintendent of one of the substations of the Texas Agricultural Experiment Station. Indeed, Professor Sanderson, official Entomologist of that state, writes me that so far as he knows, Mr. McHenry was the first man to make practical use of the blast torch against insects of any kind. He is said to have used it successfully for several years, as have others in his section of the state, but of late he has made comparatively little use of it for that purpose because of the amount of work required to go over a cabbage plant with the torch.

Professor J. M. Stedman, of Missouri, writes more confidently of its usefulness against the cabbage-bug, saying, under date of October 28, 1903, "I have not found the gasoline torch of any special value as an insecticide apparatus except in extreme cases when one has a sufficient number of the harlequin cabbage-bugs in his cabbages to cause serious trouble. I have then used this torch to good advantage. One can very readily pass over the cabbages fast enough not to injure them, and at the same time to kill the harlequin bugs. It is not necessary to have the bugs scorched sufficiently to drop at once, as I have found that they will ultimately die if this intense heat has been very rapidly applied."

This cabbage-bug is not widely destructive in this state, although it is continuously present in some parts of southern Illinois, and during one season extended its injuries as far north as Champaign, and was once found in Chicago by Mr. A. Bolter. The reported effectiveness of this torch against this insect suggests the trial of it against other bugs, which cannot be killed with arsenical poisons since they do not eat the solid substance of their food plant but merely suck its sap.

THE COTTON BOLL-WEEVIL.—The appearance in Texas of the snout-beetle known as the Mexican boll-weevil has caused general and justifiable alarm among the cotton-growers of the South, and the Texas State Entomologist, Professor Sanderson, has devoted himself to an assiduous study of the insect and has made many experiments for its

destruction and control. This is, indeed, the most important, pressing, and perplexing problem which the economic entomologist now has to deal with in the Southern States. In the course of his work against this insect Professor Sanderson has tried two forms of the gasoline torch; one, a blast-lamp known as the pear-burner, used in southwestern Texas for burning the thorns off the prickly-pear, and the other a torch sent him from Illinois by a dealer who offers and advertises it for sale for the destruction of insects. The latter was found so faulty in construction that it could not be used, and it was consequently returned.

The pear-burner, which generates a much more powerful blast than any of the smaller torches, was tried by Professor Sanderson for burning up the squares of the boll-weevil as they lay upon the ground, but so far, as he writes me October 28 of this year, he has not had sufficient success with it to indicate that it has any value for this purpose.

The only other beetles on which it has been tested by any of my correspondents are certain unspecified species found on aster by Professor Symons, of Maryland. "In this case," he says, "it was effective in killing the beetles, but one has to be so extremely careful not to hurt the flowers that I would hardly recommend it for practical use."

Experiments at Urbana.—In response to my request, made August 5, 1902, to the inventor and patentee of a modified form of the gasoline torch intended especially for insecticide work, one of his instruments was sent me with directions for its use, and was at once put into the hands of my most experienced field assistant, Mr. E. S. G. Titus (now assistant to the United States Entomologist), who, with the aid of another assistant, Mr. George I. Reeves (now an assistant in the Entomological Department of the University of Missouri), tried it at various times during the following two months on such kinds of injurious insects as could be found in any number at Urbana at that time of the year. It was further tried on a fungus parasite of the lilac leaf, and on various kinds of vegetation to determine the effect on the plants of an exposure sufficient to kill the insects infesting them. Although sent me expressly for experimental purposes, this instrument proved to be relatively so weak in action that its use by us should probably be regarded as a test of the value of this kind of a torch rather than that of the torch method in general; and it is on this account that I have kept our own statements separate from those made to me by others, most of whom seem to have worked with a more efficient apparatus.

The results of our various trials are here given as reported to me by Mr. Titus at the close of his series of experiments, about October 20.

"The torch is simply an ordinary "plumber's torch" fitted with a two-gallon gasoline tank and a three-foot piece of rubber tubing. A short iron discharge pipe connects the rubber tubing with the torch.

"Filled the tank about half full of gasoline according to directions.

The valve in this pump was of leather and by no means circular in outline, and it was at first rather hard to secure even pumping pressure. The connections were all very dry and needed soaking. After an hour or so of work, cleaning the discharge pipe and burner, we were able to light the latter and get a flame.

"Under the heaviest pressure obtainable—sufficient to force air bubbles from the pump valve and at the cut-off in the base of the pump —the flame was tried at varying distances. At fifteen inches from the burner the heat was scarcely sufficient to singe the hair from the hand, but a little closer, ten to twelve inches distant, it would singe. The burner was used when running at full force. The effects were about as follows, examinations being made at several days' interval.

"The trunk and smaller limbs of an apple-tree were thoroughly treated. This tree was badly infested with Forbes and scurfy scales, and also had on it considerable woolly aphis. The last mentioned insects were killed where they were completely burned off the limb; but where only the woolly covering was burned off and the insect not actually caused to drop, there was little apparent injury. The Forbes scale appears not to have been injured, except the young not yet old enough to form a scale. The scurfy scale was not injured. The smaller limbs were sufficiently treated to cause the bark to blister in spots, without having any apparent effect on mature scales of either kind.

"I have tried the burner under ordinary pressure at different times against various other insects and foliage. A colony of fall web-worms in a box-elder tree was treated, and a number of worms that fell were placed in a cage in the insectary. These were given plenty of fresh food, and did not appear to be inconvenienced by the lack of hairs on their bodies. They grew, and some of them pupated. Most of the remainder were parasitized, and the few that died were full grown at death. The parasites emerged in due time and were preserved.

"Arctian caterpillars (woolly bears) treated to the full force of the burner for ten to fifteen seconds, or even longer, had the hair thoroughly singed from their bodies, and some were blistered. The majority of these finished their growth and pupated. I could see no greater mortality among them than ordinarily occurs with this species under insectary conditions. Several cabbage-worms were treated until they rolled from the leaves. Most of these were not permanently injured, and those that died were burned so badly that the outer skin was broken. To produce this effect upon a caterpillar it must be treated with a direct blaze long enough to cause the leaves to curl and blacken on the plants.

"Meadow moths (*Crambus*) flying about in the grass were singed with the flame. Some of these would fly through the flame so close to the burner that the hair on one's hand would be quickly singed off, but they

were usually uninjured by this experience. To kill one of these moths it had to be followed with the flame until some parts were burned sufficiently to cause it to fall, when it could, of course, be easily disposed of.

"Lilac leaves badly infested with mildew were thoroughly treated, the burner being held at varying distances and acting for varying periods of time. The mildew does not seem to have been affected where the leaves were not injured, and was rarely affected where the leaves were burned sufficiently to cause them to curl and later to wither. Leaves that were treated to the flame for three seconds dropped off. Other leaves treated one second remained on the bush and were not perceptibly injured. Between these two times (which really represent flashing the burner over the surface, and holding it there for an instant) the leaves showed varying injuries. At first the mildew appeared to have been burned off, but specimens which had been thoroughly treated and left in the insectary, were again covered with the mildew in five days.

"Elm, Osage orange, box-elder, apple, cherry, plum, grasses, nasturtiums, cabbage, pine, cedar, *Amorpha*, walnut, rose-bushes, peach, and several other trees and ornamental shrubs have been treated at various times. I find that when the flame is held close to the foliage for a few seconds this is visibly injured. If held a short distance away the injury is not so great, but usually shows after a few days by the blackening of the leaf or by the browning and curling of the edges. Often leaves so treated will drop off.

"To sum up: The use of sufficient heat to destroy effectually insect larvæ of the kinds we treated, will injure the foliage and often the twigs."

Final mention may be made of a trial of the torch by Mr. Mally, in Ohio, in 1898, the details of which can not now be given because the record is not accessible. This torch, obtained from Illinois, was put into Mr. Mally's hands by Professor F. M. Webster, with instructions to give it a thorough test. It was taken by Mr. Mally on one of his field trips, used on a variety of insects, including the chinch-bug, and returned with the general report that it was unsatisfactory for its purpose.

Professors Webster and Pettit agree in a statement of its usefulness and convenience for "thawing out frozen water pipes."

Conclusion.—Notwithstanding the generally unfavorable character of the statements made to me concerning this torch by those best able to judge of its value, it seems to me that it may have a limited field of usefulness secondary to other measures for the destruction of certain kinds of injurious insects. One such use has already been suggested in the preceding paragraphs on the San Jose scale. It should certainly be tried for such bugs (*Hemiptera*) as can be lured away from valuable crops to so-called trap crops of worthless plants. It might profitably be tried in comparison with other adjuncts of the trap and barrier method for the destruction of chinch-bugs as they come out of small grain for

their midsummer invasion of fields of corn. Exact experiments should be made on the after effects of brief exposure to its flame, as reported by Professor Stedman for the harlequin cabbage-bug, and by Mr. Titus for the fall web-worm and other caterpillars.

It should be remembered, however, that it is probably the most dangerous to vegetation of any insecticide apparatus which has ever been brought forward for common use, and it consequently should not be generally recommended for use on living plants of any value until it has been so thoroughly tested under various conditions that a safe method may be described in terms which cannot be misunderstood or misapplied by any ordinarily intelligent and reasonably careful workman.

Thanks are due to the various gentlemen who have kindly communicated their observations for my use, and also to Professor M. V. Slingerland, of Cornell University, who obtained for me the information above reported concerning a test of the torch made in New York by Professor Craig.

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